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The Lightning Discharge*

The Halley Lecture delivered on 28th May, 1937, *by Professor B. F. J. Schonland*

There are few problems in meteorology more fascinating than that of the thunderstorm. It is a many-sided problem: how is the electricity generated; what part does the precipitation play; where does the lightning originate; what exactly takes place in the lightning discharge ?

Professor B. F. J. Schonland and a band of enthusiastic workers in South Africa have attacked the last of these problems with remarkable success, and it was very appropriate that when he was invited to deliver the Halley lecture at Oxford, last year, he should make "The Lightning Discharge" the subject of his discourse.

Many workers, in particular Professor B. Walter of Hamburg, have used a moving camera as a tool in the study of the lightning flash, but they were always up against two difficulties: first, with a rotating camera it is difficult to obtain sufficient speed to separate out the rapid changes, and secondly it is not possible to separate changes due to time and changes due to the non-linear shape of the discharge channel. Both these difficulties were overcome by Professor (now Sir) Charles V. Boys by means of a stationary camera fitted with two lenses attached to the ends of a rapidly rotating arm. With this camera it is possible to determine with great exactitude

* B. F. J. Schonland, O.B.E., M.A., Ph.D. The lightning discharge, being the Halley Lecture delivered on 28 May, 1937. Size 9 in. × $5\frac{3}{4}$ in., pp. 19. *Illus.* Oxford, at the Clarendon Press, 1938. 2s. net.

the time sequence of points on the image of a lightning flash, intervals of a few micro-seconds being easily measured. Boys, having proved the success of his camera, but despairing of ever being able to use it in this country except on very rare occasions, presented it to Schonland to use in South Africa where thunderstorms are more frequent and the flashes are less obscured by low clouds. Seldom has such generosity been more amply repaid.

The Halley lecture itself was a condensed summary of six years' work; it is therefore clear that in a short article like this it is only possible to give the broadest outline of the conclusions reached; the lecture itself, or better still the original papers in the *Proceedings of the Royal Society*, must be consulted for details.

A lightning flash when viewed by the naked eye appears to consist of a channel more or less branched extending from the cloud to the ground; usually the flash appears as an instantaneous discharge, but occasionally it appears to remain for a sensible time and sometimes actually to flicker. The moving camera showed that the luminosity does in fact persist for an appreciable time and that not infrequently after one discharge has passed, another discharge uses the same channel. This may be repeated several times, thus accounting for the flicker. Walter, using a camera rotating at a steady speed about a vertical axis, was able to measure these times and to record the number of discharges which passed down the same channel before it disappeared. It is usual now to speak of the whole series of discharges along the same channel as a "lightning flash" and to describe the individual discharges as "strokes" or "partial discharges".

The outstanding result of the work in South Africa has been to show that every lightning flash is preceded by a leader stroke which opens up a channel between the cloud and the ground and it is only when this leader stroke reaches the ground that the main highly luminous discharge travels upwards from the ground to the cloud. The leader stroke, which is nearly non-luminous, cuts its way through the air in a series of short advances or steps and may be highly branched. The return streamer starting where the leader strikes the ground passes upwards along the channel left by the leader and along each of the branches so that the whole track of the leader stroke is marked out in brilliant light. The whole process is shown diagrammatically in Fig. 1, reproduced from Schonland's lecture. The base of the cloud is shown by a heavy line and it is here that the flash first becomes visible; but it is important to remember that the flash does not start *on* the cloud but *within* the cloud and it may have travelled for a kilometre or two within the cloud before appearing below the cloud.

Starting then within the cloud the leader stroke first appears as it leaves the cloud and moves downwards at a rate of about 200 km./sec.; at *a* of Fig. 1 it is shown when it has progressed some distance towards the earth. The whole channel is conveying negative

electricity which it distributes into the air along the branches. At first the direction of the path and the points of branching are determined by fortuitous conditions at the end of each branch and not at all by features on the surface of the ground. When, however, the tip of the longest branch approaches the ground as at *b*, very strong electrical fields are set up between the end of the channel and the ground. From irregularities on the ground, positive electricity streams out to meet the negative electricity in the approaching channel. Contact is made between the channel of the leader and the channels from the ground and the first part of the flash is over—see *c*.

The leader stroke has not only conveyed a large amount of negative electricity from the cloud and left it in all its channels; but those channels are highly conducting. In fact at the moment that the leader stroke reaches the ground the conditions are almost as though a wire had been stretched between the negative charge within the cloud and the induced positive charge on the earth. Along this channel positive electricity from the ground passes upwards to meet and neutralise the negative electricity in the branches and in the cloud. This process takes place at a rapid rate, the positive electricity moving upwards at 20,000 km./sec.; i.e., 100 times as fast as the leader stroke moved downwards. The current carried by this return streamer is very great and causes intense luminosity in the channel. This is the stage of the process which produces the blinding light of a lightning flash. As soon as the positive electricity has reached the upper end of the channel, which is well within the cloud, the flow ceases and the luminosity of the channel fades away. The air in the channel, however, remains in the conducting (ionized) state for a relatively long time after the glow has ceased to be visible.

In most cases this is the end of the lightning flash; but occasionally the whole process starts again almost immediately. According to a later paper by Schonland this is due to a discharge starting from another portion of the cloud. According to this explanation a new leader starts, but it does not travel towards the ground but towards the end of channel left by the previous stroke. On reaching the top of the channel it finds a conducting path reaching down to the ground and naturally it follows this path rather than blaze out a new path through the air. Owing to the use of the conducting channel this second leader stroke is able to travel faster than the first, its velocity being 2,000 km./sec., i.e., 10 times faster than the first leader but still only a tenth of the velocity of the return streamer. This second leader stroke travelling down the old channel does not use the branches, but only the main path to earth, so that strokes subsequent to the first one are not branched. On reaching the ground it releases a second return streamer which again illuminates the channel from earth to cloud. This process of leader followed by return streamer may be repeated many times—in another paper Schonland says that as many as 40 successive strokes have been observed.

There is not space here to refer to a number of other points dealt

with by Schonland in his interesting lecture but the following typical timetable may be of interest. The leader stroke takes about ·01 sec. to travel from the cloud to the ground and the return stroke ·00004 sec. to reach the cloud and probably twice as long to reach the end of the channel so that the luminosity lasts less than one ten thousandth of a second. If there are subsequent strokes along the channel the total duration of the flash may well extend to a tenth of a second and in extreme cases to a whole second.

The work done by Schonland and his colleagues has been very great and so thorough that full reliance can be placed on the conclusions reached. At the same time only a very small portion of the problem of the lightning discharge has been touched. All the flashes investigated in South Africa have been discharges from a negatively charged cloud to earth. There is still the problem of the discharge of a positively charged cloud which must be entirely different and probably takes place without a leader. Then there is the problem of where and how the discharge commences. There is reason now to believe that this is always within the cloud but it is not known whether the primary discharge is between two differently charged cloud layers and the flash to earth only a secondary effect. Then there is the final problem of the strength of the field necessary to initiate a discharge. The Bernard Price Institute of Geophysics at Johannesburg has been founded largely to carry out these investigations under the direction of Professor Schonland and we wish him and his co-workers all success.

G. C. Simpson.

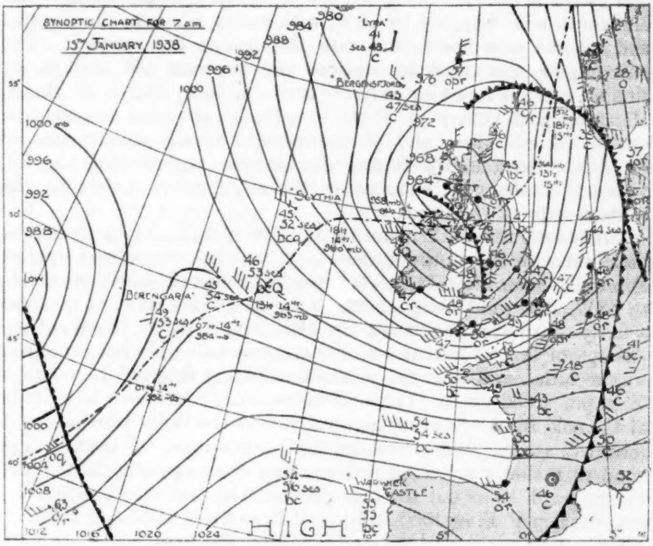
The Gale of January 14th–15th, 1938

By F. H. Dight, B.Sc., A.Inst.P.

Intensely cold weather over practically the whole of the continent of Europe had, for a lengthy period, both before and after Christmas 1937, almost continuously threatened at least the southern half of Britain with a spell of really cold weather. The intrusion of the milder conditions from the south-west just before Christmas for a time suggested that a complete change of type might result, but the year closed with the mainly quiet conditions which had characterised the autumn, still persisting. It was about a week later that the "westerlies" were finally established and local gales occurred chiefly round the south-western coasts. By January 11th the further change to a mild stormy type of weather with prevailing south-westerly winds was definitely indicated, and this spell was to prove unusually persistent. Gales were reported somewhere in the British Isles on 22 days between January 8th and February 1st, and on several days affected considerable areas of the country. The first major gale of the winter swept the western and northern coasts on the 12th and 13th, and was severe at times off west

Scotland where Stornoway and Tiree, both in the Hebrides, experienced gusts of 87 m.p.h. and 77 m.p.h. respectively. The renewal of the gale on the following day was to prove more violent and destructive than its predecessor and developed into the most widespread gale experienced over the country as a whole for a considerable time.

The earliest signs of a new formation were detected on January 11th off the American coast north of Florida, but for two days this remained quiescent whilst drifting slowly east. The first definite indications of the new disturbance appeared on the chart for 1300, January 13th, in Lat. 38° N. Long. 37°W., the central pressure



being 1008 mb. At this stage the warm front of the new depression became associated with the retrograde cold front of the major low pressure system covering most of north-west Europe, and five hours later it was apparent that a large warm sector with air temperatures of 63° F. to 66° F. was operating to cause considerable developments which thereafter proceeded apace. The subsequent behaviour of the new system is shown on the figure on which successive positions of the centre and the central pressures are given. Six hours later strong winds were reported in the vicinity of the centre; the SS. *Bristol City* south-westward of the centre in Lat. 47·5° N. Long. 17° W. reported " Storm SW. 11 " and the *Holystone* nearly 200 miles

further east had a "whole gale" SW. 10, and Beaufort force 9 was reported as far south as the Portuguese coast. The Master of the *War Bahadur* reported squalls of hurricane force and mountainous seas at midday, and by 1500 estimated the wind as a full hurricane Beaufort force 12 with gusts of 100 m.p.h., the sea precipitous and dangerous about 60 ft. high. A wave which caused major damage he estimated at 70 to 80 ft., and goes on to add that the storm was still at its height at 1800, with visibility nil and hundreds of tons of water breaking over the ship.

The fall in pressure had set in over south-west Britain by 0700 on the 14th and by 1300 winds had freshened to force 7 from between SE. and S. with rain on the south-western coasts of the British Isles and round Brittany. Gales had spread across Ireland, South Wales and south-west England by 1800, with strong winds in the Channel and on the east coast, and rain throughout the country. The autographic records from stations in the west are remarkably similar, and the following extracts from a note by Mr. G. W. Hurst, Meteorological Officer at Pembroke Dock, after an examination of the records there and of the records of the anemometer at St. Ann's Head in the centre of the area experiencing the full violence of the gale, summarises the sequence of events on the western side of the country :—

"After a further 12 hours (from 1800 G.M.T., 14th) there was little warm air left on the surface. . . . The warm front reached Pembroke soon after 1430 when the wind veered slowly from SE. to SSW., the wind being about 40 m.p.h. at this time. There was a fairly sharp veer at 1920 on the 14th from S. by W. to SW. at the passage of the cold front which was remarkable in that no squall was recorded and that the wind immediately dropped from about 50 m.p.h. to 30 m.p.h. (This phenomenon of a decrease in velocity at the cold front was even more marked at the Scilly Isles, and was recorded at Holyhead, Sealand and Aldergrove. F.H.D.) The wind then slowly increased to reach gale force again by 2200. The thermograph bears out the times reasonably well—the temperature rose sharply 1° F. at 1530 and fell 1° F. between 2030 and 2045. . .

Gales were particularly fierce in the Irish Sea area, where the wind maintained at over 50 m.p.h. for many hours : very high gusts were recorded. The following figures from the anemograph at St. Ann's Head during the period of the gale are striking. By 1400 on the 14th the wind reached an average of 40 m.p.h. and except for a spell between 1930 and 2200 on that day, it remained above 40 m.p.h. until about 1800 on the following day. From 0300 to 0700 on the 15th the wind averaged nearly 70 m.p.h., and a gust of 101 m.p.h. was recorded. The wind gusted to over 90 m.p.h. on many occasions".

The depression had attained its lowest pressure, about 958 mb., just off West Ireland at 0100, January 15th ; winds had increased

to gale force over most of the country and widespread gales extended at least 600 miles westwards across the Atlantic and southwards to the coast of Portugal. Winds were everywhere increasing and had already reached 71 m.p.h. in a gust at Scilly, whilst by 0700 gust speeds (additional to that at Pembroke) of 78 m.p.h. had been recorded at The Lizard, 75 m.p.h. at the Scilly Isles and 68 m.p.h. at Holyhead.

On the eastern side of the country the winds veered from S. and SW. to W. during the forenoon and immediately increased to their maximum intensity. Meanwhile the gale continued unabated in the west, where some places had their maximum gusts round the middle of the day before the gale at long last began to subside. The final phase of the gale occurred in Scotland and north-east England toward evening and developed well behind the centre of the disturbance.

The prolonged duration of the gale at Pembroke has already been referred to: at Mount Batten (Plymouth) the gale was continuous for 22 hours, at the Scilly Isles there was a temporary break after three hours followed by a continuous blow for 15 hours. At the Lizard it maintained at gale force with interruptions for a total period of 12 hours, at Holyhead and Cork for 11 hours, but for five hours at Spurn Point, three hours at Tynemouth and only two hours at Eskdalemuir.

Some exceptionally rapid falls of pressure occurred with the advance of the depression, the most noteworthy being a fall of 11·8 mb. at Valentia in the three hours preceding 1300 on the 14th, one of 15·0 mb. at Malin Head between 1500 and 1800, and a negative tendency of 10·0 mb. reported from Blacksod Point at 0100. The total falls in pressure were large and varied across the country from 47 mb. at Scilly and 44 mb. at Blacksod Point to 35 mb. at Aberdeen and to 27 mb. at Stornoway and Croydon; these are considerably larger than those noted during the gale of January 12th, 1930. Pressure rose at the rate of from 9 to 12 mb. in 3 hours in the rear of the disturbance near the track of the centre, but tendencies were not unusually pronounced elsewhere.

Rainfall on the whole was not unduly heavy, averaging roughly about 0·5 in. along the track of the centre of the disturbance; 0·85 in. was measured at Colwyn Bay, 0·64 in. at Morecambe and 0·61 in. at Harrogate. The limited reports to hand indicate considerably heavier falls exceeding one inch in the hill districts, the largest fall so far reported being 3·35 in. in Westmorland.

It is of interest to note that on this occasion the completely developed system travelled some 700 miles across the Atlantic, whereas in the general case, severe and widespread gales in this country are associated with active secondary disturbances which develop relatively close in to the British coasts and then move quickly across the country.* The system had just begun to occlude

* *London, Met. Mag.* 70, 1935, p. 229.

at 0700 on the 14th, and six hours later when it was occluded to a point within 150 miles due west of Valentia, the warm front was located approaching Valentia extending east-south-east to The Lizard and across to central France. The cold front stretched almost due south towards Corunna and then recurved south-westwards. The cold front had reached the line Aberdeen–Croydon–Lisbon by 0100 on the 15th, and an important development occurred at about this time. The change of direction in the track of the centre will be noted on the chart, whilst the wind S.7 at Blacksod Point, with a tendency of —10·0 mb. is significant. Unfortunately there are no autographic records available to assist in the solution; the original bent back occlusion already noted on the Atlantic must have been well in advance of the vital position. It is certain that a small "bulge," if not an actual small centre, developed over or near NW. Ireland and whilst this moved north, the main centre came through on an easterly track across north Ireland and north England. With the highest pressure located far to the southward and the steepest pressure gradients to the south and south-west of the centre, conditions were in favour of the change to an easterly movement of the centre after its occlusion. At least one half of the total fall in pressure occurred subsequent to the passage of the cold front and the gale reached its greatest intensity in the Irish Sea area rather later than 0400 with definite frontal indications. This front is shown on the chart for 0700 on the 15th, extending from just north of Ireland to about Ross-on-Wye. C. K. M. Douglas considers that this front resulted from the change in motion of the system following occlusion of the centre and probably from the convergence into the "isallobaric low" engendered by the development. It was with the passage of this front that the winds attained their maximum speeds also in the eastern counties. Once over the North Sea, the centre turned sharply northwards; it appears to have filled up fairly quickly and was lost as a separate entity.

Shipping, in the main Atlantic routes westward to mid-Atlantic, was caught in the direct path of the storm whose fury remained unabated until it had swept across the whole of the British Isles. Photographs in the daily press, of the extensive damage to the superstructure of the Government tanker *War Bahadur* which arrived at Plymouth on the evening of the 17th, after having jettisoned some of its cargo, eloquently depicted the violence of the storm in mid-ocean, where the freighter *Cragpool* was also in difficulties for a time. Further east, the maximum force of the gale was experienced in the Irish Sea area where two steamers were reported to have foundered with a feared loss of 22 lives, whilst at least three other men lost their lives following accidents to two more coasting steamers, and others were injured. Lesser mishaps at sea included a collision between two British ships in the Thames, whilst the cross-Channel steamer *Isle of Thanet* was

in collision with the quayside at Folkestone. Around the coasts of Wales, Lancashire and Cumberland the gale was coincident with some of the highest spring tides. At Aberystwyth the high seas completely destroyed a portion of the promenade and caused other extensive damage and flooding to some of the hotels and other buildings near the front. The sea defences were damaged with consequent flooding at various other points along these coasts, and in west Cumberland the railway embankment was washed away after the sea wall had been demolished. Inland, with the exception of one fatal accident in Westmorland, the damage was confined to fallen trees and hoardings. A phenomenon noted with previous heavy gales* was reported from Ross-on-Wye where a "salty" deposit was observed on the glass sphere of the sunshine recorder after the gale, evidence of the amount of salt spray driven well inland by the wind. Extreme velocities registered during the gale in the west were a gust of 101 m.p.h. at St. Ann's Head, 86 m.p.h. at Holyhead, and 82 m.p.h. at the Scilly Isles. A gust speed of 100 m.p.h. was previously recorded at St. Ann's Head in January, 1936, and one of 107 m.p.h. at Holyhead in February, 1937. Wind velocities of 100 m.p.h. or more have now been recorded 12 times in various parts of the British Isles.†

In the south 70 m.p.h. was registered at Calshot, 68 m.p.h. at South Farnborough and 62 m.p.h. at Croydon and Lympne during the forenoon. The maximum gusts recorded in the north-east of the British Isles included 70 m.p.h. in gusts at Eskdalemuir and Aberdeen, and 69 m.p.h. at Catterick.

Events have proved that the gale described above was to be but one of a series of recurrent, widespread, heavy gales in many parts of the United Kingdom. January merged into February with gales still whining and howling from Lands End to John o' Groats.

The Aurora of January 25th–26th, 1938

On the evening of January 25th a magnificent display of aurora was observed over the British Isles, continuing until the early hours of the 26th. According to newspaper reports it was also seen over most of Europe and in the Mediterranean, and it was probably still more widespread. Information from an incoming Union Castle liner states that it was observed as far south as Madeira.

The aurora was accompanied by a great magnetic storm. This, at Abinger, was more intense than any recorded by the Greenwich observers since that of September 25th, 1909. The disturbance began just before noon on January 25th, but up to 1600 G.M.T. did not exhibit unusual intensity. By 1800, however, it was evident

* *London, Met. Mag.*, 62, 1927, p. 277 and 63, 1928, p. 131.
† *London, Quart. J. R. met. Soc.*, 62, 1936, p. 195.

that a great storm was beginning and this continued until about 0200 on the 26th. Solar activity is now at or near the maximum of the present cycle, but at the time of the magnetic storm the sun's visible hemisphere showed no large spot. A great sunspot passed the sun's central meridian at about 1000 on January 18th, this being one of the six largest sunspots photographed at Greenwich since 1875. By January 25th this had just passed out of sight at the western limb, where a great prominence display was observed over it.

Occasional auroral manifestation is not uncommon in the south of England but great displays are rare. It has been stated that the recent aurora was the finest so seen in the last 50 years, but it is difficult to make any such statement with confidence, since memories are proverbially short and for real comparison the same person should have viewed the aurora on all occasions. The last notable aurora in the south of England occurred on December 25th, 1918. I saw this at Bournemouth and the display was in every way inferior to the recent one. From 1881 to 1917 there were, I think, only six notable displays, two of which were seen in 1882, and one in 1917. It is sometimes stated that aurora is only seen in the south of England in the years of high or maximum solar activity, but this is not the case. Dr. C. L. Prince's book, "The Topography and Climate of Crowborough Hill, Sussex," contains monthly notes on phenomena observed during 1871 to 1897. Aurora was seen on 18 nights in the 27 years. Only 10 of these occasions fell within 5-year periods centred on the dates of maximum solar activity, while two were at times of minimum activity.

Many observations of the recent aurora have appeared in newspapers, but the description given here is confined to accounts received by the Meteorological Office. The aurora began in south-east England at about 1815. Mr. A. E. Moon saw it at this time at Hastings. Leaving Wadhurst Station, Sussex, at 1830, I saw a bright auroral arch which I was told was not visible at 1800. My last observation was at 0100 on the 26th and aurora was not seen at Greenwich Observatory after 0115. The duration was thus about seven hours. Father J. Ellsworth-Norton, S.J. saw it earlier, at 1745, at Chipping Norton, Oxon. Mr. Morgans first saw aurora at Catterick at 1815, and it was still in progress at 0200. Mr. S. E. Ashmore, of St. Asaph, cycling for some hours in the Wrexham district, saw it at 1820 and it was still continuing at 0145. The duration further north was therefore somewhat longer.

The aurora presented many interesting features, apart from its duration. Save for one relatively stable period, change was continuous, making accurate sketching almost impossible. With the exception of the great fully-developed curtains seen in arctic regions, every variety of auroral manifestation was seen in south-east England, and the colour effects were magnificent. A striking feature was the extent of light south of the zenith, and even on the southern horizon. The quickly-changing aurora of varied types is

perhaps characteristic of those produced in relatively low latitudes by great magnetic storms. Two auroræ which I saw in September, 1932, in the western North Atlantic, when solar activity was low, were of different character. Although somewhat brighter, they showed less variety, with perfectly regular arches at times, did not reach the zenith and had no red coloration.

The rapid changes make identification of features seen by different observers difficult. The two red rays at 2205 sketched by Mr. D. L. Champion, of Goff's Oak, Herts (Fig. 1) were, however, drawn in the same position at 2200 by Mr. L. Cundall, Morden, Surrey.

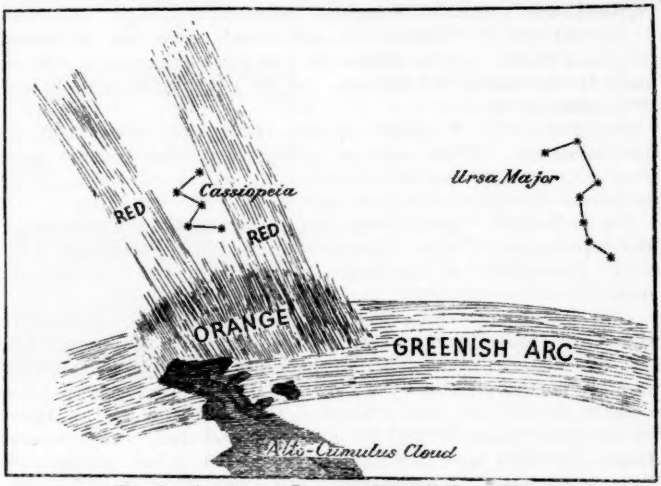


FIG. 1.—AURORA OF JANUARY 25TH, 1938 AT 2205

Mr. Champion writes: "The beautiful rays, of carmine tint, rising from the greenish arc of light at 22h. 05m., G.M.T. practically reached the zenith, the two rays enclosing the constellation of Cassiopeia, as shown diagrammatically . . . The greenish light of the arc was so intense as to completely mask stars of all but the 1st magnitude." He also states that aurora has been seen in his district only twice before in the past 30 years.

The display at Wadhurst can be broadly divided into eight periods, a brief summary of which is given below:—

(i) 1830–1855. Bright irregular arches and few rays. Arches often very complex. No red coloration.

(ii) 1855–2015. Development of rose-pink rays, at first at the west and east ends of the arches. Rapid arch changes, with intense luminosity of small areas at times. At 1915 little vertical brushes appeared along the upper edge of the lower arch, flashing up almost instantaneously in succession from east to west. Great bands

of red rays formed and changed, with much variety of colour, rose-pink, crimson, orange, purplish-red, etc. From 1915 to 1945, the sky high in north and north-east was suffused with a deep blood-red colour, tending to violet, of low luminosity. This period culminated in the great "flame" aurora, from 1950 to 2005; the whole northern sky, from west to east and up to near the zenith was covered with bright flame-coloured light, obliterating the arches and giving, as Mr. Moon writes, "the impression of a great fire reflected on a cloud sheet." Definite red rays were conspicuous on this background. The red light ended about due east in a nearly vertical curtain, hard-edged against the starlit sky.

(iii) 2015–2100. Absence of red colour, save for occasional rays and bands. Arches prominent and great extension of whitish light to the zenith and beyond. At 2035 the luminosity covered two-thirds of the sky.

(iv) 2100–2142. Irregular patches only. No arches and no red coloration. White and greenish-white patches covered large areas, with a pale blue one at one time low in north-west. Large luminous areas in the southern sky, notably through Orion.

(v) 2142–2215. Arches reformed, quickly followed by great development of red rays. Patches continued in southern sky.

(vi) 2230–2330. At the intervals of observation, bright arches only.

(vii) 2353–0030. Great resumption of activity and redevelopment of red rays, providing the finest spectacle next to that of period (ii). For five minutes from midnight there was very marked flickering in north-north-west about the apex of the arch. Ill-defined patches flickered in and out, and sections of the lower arch in the region of the apex flickered brightly into view and disappeared several times. At 0015 rays, greenish below and red higher up, radiated from points along the entire length of a bright greenish-white arch.

(viii) 0100. Three white rays in north-north-west and remnants of an arch.

The stars were very bright before the aurora began. At their brightest the arches threw a definite shadow of one hand on the palm of the other and illuminated the garden with a faint light. The arches were double for the greater part of the time; Dr. Prince states that the second arch is very rarely seen in the south of England. Both arches were always irregular, in greater or less degree. Fig. 2 shows their structure at 2030. I have called the lowest part the "arch curtain"; it was not separated from the second arch by a dark space and it was of a very uniform appearance, with a tendency to "fold" at its lower, clear-cut edge. The altitude of the arches varied much, the maximum for the main arch being about 45°. Sudden brightening of the whole arch occurred at times, with a change to a generally ill-defined appearance, and colour change from greenish-white to greenish-yellow. Rayed arches were seen

for short periods, and also by Mr. Morgans, the arch being built up of short separated radial rays. There were intermediate stages when the dark segment below the arch projected into it in innumerable sharply-pointed spikes. In spite of the rapid changes there were no rays of which the movement along the arch could be followed with the eye; this was a prominent feature of the aurora of 1918. The east and west ends of the arches were the most active regions during much of the time. It will be noted that aurora south of the zenith was confined to the period 2015–2215.

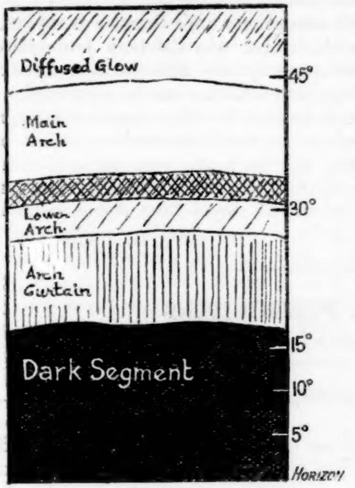


FIG. 2.—STRUCTURE (DIAGRAMMATIC) OF THE ARCH AT 2030, WADHURST.

I saw no complete corona, though the ends of some of the great red rays formed the quadrant of a circle near the zenith at 1950. Miss C. M. Botley, observing at Hastings the finest part of the display, between 1945 and 1952, saw a corona momentarily formed. Mr. Morgans saw a corona from 1947 to 1955, in which rays diverged from near the Pleiades to the horizon in all directions except extreme east. The main colour was green, with red towards the base of the cone of rays. The corona reformed at 2035 and again at 0200. Mr. Ashmore saw a bright red corona at 2040, the radiant point being 10° due south of the zenith. He states that every form of aurora was seen, the curtain and the arch being at first predominant. At one time the light reached to 30° south of the zenith. Mr. Cundall saw a purple patch at 2130, which moved into the western sky. The most striking observation of unusual colour was the great indigo patch of feeble luminosity seen due south about 2100 by Dr. C. E. P. Brooks at Ferring, Sussex. This extended from the horizon to about 45° and was separated by greenish luminosity from a great indigo band extending from near the west point up to the zenith. Closely north of this in azimuth was a vertical rose-coloured ray. Rippling and pulsating appearances are referred to by Mr. Parsons, of Ross-on-Wye, Mr. Morgans and Mr. Moon. Mr. Parsons thinks that the aurora was inferior in luminosity to that seen at Ross on October 1st, 1919. He appears to have seen little red colour and the light never quite reached the zenith. The aurora was well seen by Mr. J. Phillips at Dalwhinnie, Inverness, and by Mr. R. K. Pilsbury at

Lee-on-Solent, who describes the red glow as bright enough to be visible in a brightly-lit main street.

At the time of the "flame" aurora in south-east England, Mr. Morgans in Yorkshire was observing the corona, with mainly green rays. From 2000 to 2025, Miss M. C. L. Bowden, at Dovercourt, Essex, saw two separate red belts pierced at intervals by pale yellow rays. During this time the flame coloration at Wadhurst was rapidly dying out and by 2015 the greenish arch was the only prominent feature. These observations indicate a totally different appearance of the aurora at the same time in places rather widely separated.

Solar activity should continue to be high for some time and further auroral displays may occur during the next year or two, but it is unlikely that such a fine aurora will be again seen, at any rate in the south of England. The chances of another display after an interval of one solar rotation (about 27 days) from January 25th are not great.

E. W. Barlow.

OFFICIAL PUBLICATIONS

The following publications have recently been issued:—

Professional Notes

No. 78. Upper Winds at Kingston, Jamaica. By S. Proud, B.A. (M.O 336r).

In this note 11 years' pilot balloon observations are examined and reveal a well-defined wind structure above Jamaica. The trade wind blows mainly from E. or SE. at Kingston and extends upwards through several kilometres before being superseded by the counter-trade, which is an extension southwards above the trade winds of the westerlies of temperate latitudes. The tables and wind roses incorporated in the note demonstrate that the surface of separation between the trade and counter-trade slopes upwards towards the south and experiences a north and south seasonal oscillation which shows a time lag of approximately two months behind the sun; wide diurnal variations in the height of the base of the counter-trade also occur. Several high ascents to 15 Km. or more indicate the existence of an easterly current above the counter-trade. On rare occasions the trade wind was absent at all heights above Kingston, and it is shown that in such cases either the main polar front was in the neighbourhood of Jamaica or a tropical storm was forming in the surrounding seas.

Professional Notes

No. 79. Upper winds measured at M/Y Imperia, Mirabella Bay, Crete. By J. Durward, M.A. (M.O. 336s).

Observations of upper winds at Crete are of great importance for aircraft operating between Athens and Alexandria. A pilot balloon

station was opened in 1934 but it was unfortunately necessary to make the observations at the seaplane base at Mirabella Bay where it was felt that the results would be vitiated by vertical and eddy currents.

In Professional Notes No. 79 the author, in addition to giving summaries of the results in the form of tables as recommended by the International Commission for Air Navigation and in direction-constancy diagrams, discusses the validity of the observations. The method adopted is to compare the measured wind with the wind computed from the pressure gradient on the current synoptic chart. This was done on 204 occasions and on 52 (i.e. about 1 day in 4) there was a marked discrepancy between the two measurements. These 52 occasions are discussed in some detail and the conclusion reached that the majority of the discrepancies may be explained by a quasi-permanent eddy in the lee of Mount Oxia and Mount Pyrgos. The existence of this eddy is often revealed by the white squalls which occur at its forward edge and by the very difficult landing conditions frequently experienced by flying boat pilots.

It is found that in the majority of these doubtful cases, the gradient wind and the wind measured at 3,000–4,000 ft. are in close agreement.

Discussions at the Meteorological Office

The subjects for discussion for the next two meetings are :—

February 28th, 1938. Mr. C. K. M. Douglas, B.A., will describe a series of cloud films recently produced in Germany, and annotated by Dr. Mügge. The meeting will be held in the Science Museum, South Kensington, and will commence at 4.30 p.m.

March 14th, 1938. *Sudden disturbances of the ionosphere.* By J. H. Dellinger. Washington, J. Res. Nat. Bur. Stand., 19, 1937, pp. 111–141. *Opener.*—Dr. D. N. Harrison.

Royal Meteorological Society

The Annual General Meeting of the Royal Meteorological Society was held on Wednesday, January 19th, in the Society's house, 49, Cromwell Road, South Kensington. Dr. F. J. W. Whipple, F.Inst.P., President, was in the Chair.

The Report of the Council for 1937 was read and adopted and the Council for 1938 duly elected, Dr. B. A. Keen, F.R.S., being elected President.

A By-law authorising the titles and abbreviated titles to be used to indicate the various classes of membership of the Society was adopted.

The Symons Gold Medal for 1938 was presented to Dr. Gordon Miller Bourne Dobson, F.R.S., Reader in Meteorology in the

University of Oxford. (This medal is awarded biennially for distinguished work in meteorological science.)

Dr. F. J. W. Whipple delivered an address on "Modern views on atmospheric electricity." The central theme of the address was the circulation of electricity through the atmosphere. The following is an abstract:—

"Clouds from which precipitation is falling act as generators of electricity. Recent work by Sir George Simpson and Mr. Scrase supports the view that the separation of positive and negative electricity is mainly due to the impact of snow particles in the upper parts of the clouds. The snow particles bring negative electricity downwards and a current of positive electricity flows upwards to the 'Heaviside layer' to come down again in distant places where fine weather happens to prevail."

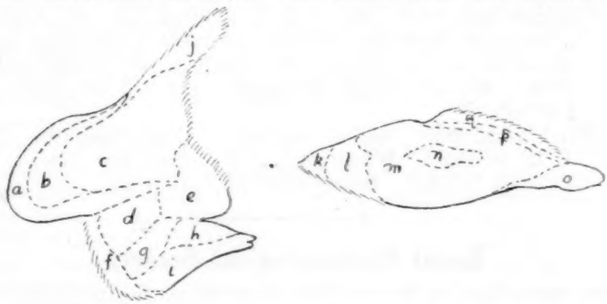
The address was illustrated by lantern slides, many of which were reproductions of autographic records obtained at Kew Observatory.

Correspondence

To the Editor, *Meteorological Magazine*

"Mother of Pearl Clouds"—January 28th–29th, 1938

Some particularly beautiful "Mother of Pearl" clouds were seen here during this afternoon. The clouds were first noticed at



(*a*) Orange and yellow.
(*b*) Reddish orange.
(*c*) Blue green shading to green.
(*d*) Electric blue.
(*e*) Green and blue.
(*f*) Magenta.
(*g*) Electric blue and silver.
(*h*) Orange.
(*i*) Silver.
(*j*) Silver grey with violet edge.
(*k*) Orange.
(*l*) Red.
(*m*) Light green.
(*n*) Blue and green.
(*o*) Electric blue.
(*p*) Orange.
(*q*) Red with yellow edges.

MOTHER OF PEARL CLOUDS
Aberdeen—January 28th, 1938

1230 G.M.T. when a small lenticular cloud could be seen between

large patches of cirrus nothus. This lenticular cloud was red in colour with green edges and at first was taken to be an ordinary form of iridescent cloud. By 1300 it was seen that there were patches of very high cloud showing brilliant colour effects in the south-west section of the sky. These were obscured at times by the passage of lower cloud. At 1400, however, the sky had cleared considerably and the clouds seen in the accompanying sketch were observed. In addition to these two clouds there were present other small faint patches of "Mother of Pearl" clouds. The clouds appeared to be moving extremely slowly from a north-westerly direction. Colour effects were still noticeable as late as 1700 after the sun had set.

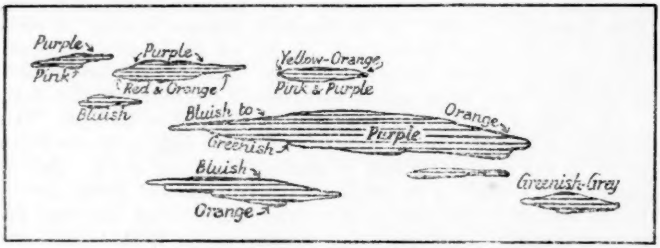
Surface conditions between 1300–1430 G.M.T.

Wind.—Force 5–6, variable between WSW. and WNW. Unusually good visibility to N., NW. and NE. from 1400–1430.

W. F. Watson.

The Observatory, King's College, Aberdeen, January 28th, 1938.

A very interesting example of luminous clouds occurred here between 7h. 45m. and 8h. 15m. on January 29th, in the south-east part of the sky at an elevation of 25° to 30° above the horizon. The attached sketch indicates the different colourings observed.



Luminous Clouds seen at Ross-on-Wye

The clouds were small lenticular cirrocumulus and had a similar glistening appearance to those illustrated in Sir Napier Shaw's book "Forecasting weather" (a photograph taken in Scandinavia, I think). They were of great beauty and striking colours—as one sees on a mother-of-pearl ornament, or when petrol has been spilled. The blue-green was very vivid.

F. G. Parsons.

The Observatory, Ross on Wye, January 30th, 1938.

NOTES AND QUERIES

Changes in Daily Weather Report on January 1st, 1938

Since 1930 the British Section of the *Daily Weather Report* has

contained a "morning" weather chart for the greater part of the Northern Hemisphere. The observations presented on this chart are not synchronous but this year a change has been made which gives approximately synchronous observations over a larger area than formerly.

Till the end of December, 1937, the chart could be divided into the following three sectors as regards hour of observation :—

Sector.	*Hour of Observation.*
U.S.S.R. (approx. 170° E. to 30° E.)	7h. local time.
30° E. to 40° W.	6h. or 7h. G.M.T. (Azores 8h.)
40° W. to 170° W. ...	0h. or 1h. G.M.T.

From January 1st, 1938, these have been reduced to the two sectors :—

Sector.	*Hour of Observation.*
U.S.S.R. (approx. 170° E. to 30° E.)	1h. local time.
30° E. to 170° W.	0h. or 1h. G.M.T.

The improvement in the charts effected by this change is most marked over mid-Atlantic. Previously a difference of six hours had existed between observations from ships on opposite sides of the line of longitude 40° W. Strictly the isobars should have shown the discontinuity when pressure changes in six hours were appreciable at points along this line; for various reasons continuous isobars were invariably drawn. In consequence pressure systems in mid-Atlantic with closed isobars and having an appreciable west-east component of motion tended to become distorted, the isobars circumscribing them being unduly elongated in the west-east direction.

The gain in one respect has meant a sacrifice in another. The network of land stations in Europe and Africa making observations at 1h. is not so close as that of stations observing at 7h. This is particularly notable in Scandinavia, the Balkans and North Africa. In the case of Iceland entries of weather, temperature and wind do not now appear on the chart, but pressure values at 1h. G.M.T. are available and are used in drawing the isobars.

A change was also made in the Upper Air Section of the *Daily Weather Report*. From January 1st, 1938, upper winds obtained from pilot balloon ascents and nephoscope observations have been reported in kilometres per hour instead of miles per hour; and heights, in the case of balloon ascents, in metres instead of feet. To obtain the approximate speed of the wind in kilometres per hour from nephoscope observations the heights assumed for medium and high cloud are 5 and 8 kilometres respectively: these are approximately the equivalents of the heights 3 and 5 miles formerly used.

Upper winds obtained from pilot balloon ascents continue to be reported for certain fixed levels but, in addition, the levels at which changes from one régime of wind to another occur, are set out at the bottom of the columns so far as space will permit.

REVIEWS

Sunspots and their effects. By H. T. Stetson. Size 8 in. × 5½ in., pp. xv + 201. *Illus.* New York and London. McGraw-Hill Book Co. Inc. 8*s.* 6*d.* net.

At the moment of writing this review, sunspots are very much "in the air," the appearance of a large spot, visible to the naked eye, on January 19th having been followed on January 25th by a most spectacular display of aurora. The close relation between sunspots and auroræ has long been known and, like the equally intimate connexion between sunspots and magnetic storms, has its seat high up in the ionosphere; changes in the ionosphere also cause marked variability in the reception of radio signals, which show a close though complicated relation to the sunspot cycle. All these effects are very clearly described and explained by Dr. Stetson in the chapters on "Sunspots and radio," and "Of Sunspots, the earth's magnetism, and carrier pigeons".

Sunspots do not stop in the heavens however; there is much support for the idea that they descend to earth and play a large part in the affairs of men. The author discusses the possibilities in a vigorous way, but he is always careful to warn us when basis of facts is slender. He deals first with "sunspots and human behaviour," and describes a number of researches which tend to show that the quality of the sun's radiation at sunspot maximum differs from that at sunspot minimum in such a way as to cause a physiological or psychological cycle in human beings. Bearing in mind the therapeutic effect of ultra-violet radiation and its great variability on the sunspot cycle, he thinks that this is probably the important factor though an electrical connexion may also be possible. "Sunspots and growing things" is mainly devoted to the investigations of Prof. Douglass into the cycles of tree-rings, which are shown by data, extending over thousands of years, to be closely related to sunspot cycles of 11 and 23 years. Relations to vintages and to animal populations are less convincing because the records are short. This criticism applies with still greater force to "sunspots and business"—business activity, manufactures in general, production of automobiles and building contracts, all supply material for striking diagrams, but in most cases these cover only one sunspot cycle and they are hardly independent witnesses. The author thinks that they are expressions of mass psychology and so share in the effects of sunspots on human behaviour, but much more evidence is required. The relations between sunspots and weather are equally uncertain, and the author limits himself to a broad general description of the principles involved, mainly illustrated by the work of Clayton and Abbot.

The astronomical parts of the book are distinctly good. Sunlight is measured from ultra-violet to infra-red without a trace of tears. To give the cash value of the light and heat supplied by the sun in dollars seems rather materialistic; when figures reach quadrillions

they are so impressive as to be unintelligible. On the other hand, the account of the source of the sun's energy, and especially the chapter on the nature of sunspots, their growth, migration and decline, are excellent examples of clear non-technical exposition, and the book ends with an interesting discussion of the causes of these disturbances. The author is an astronomer who is at present working on relations between cosmic and terrestrial phenomena ; he is also a great admirer of Dr. Abbot, to whom he dedicates a book which he was well qualified to write.

Synoptic and Aeronautical Meteorology. By Horace Robert Byers, Sc.D. Size $9\frac{1}{4}$ in. $\times$ 6 in., pp. ix + 279. *Illus.* New York and London, McGraw-Hill Publishing Co. Ltd., 1937. 21*s.* net.

Dr. Byers is in charge of air mass analysis in the U.S. Weather Bureau, and has produced a very readable book, which is not excessively technical but is nevertheless sufficiently advanced to give an adequate idea of modern meteorology. The book is intended for aeroplane pilots and others who have previously had some instruction in elementary meteorology. The treatment is non-mathematical except for the quotation of some fundamental formulae, and includes such subjects as tephigrams, Rossby diagrams, and atmospheric turbulence. Though the book deals primarily with the practical needs of aviation, it rightly starts with a chapter on radiation, since this is the foundation of all atmospheric processes. Modern synoptic methods, in particular air mass analysis and fronts, are the main theme of the book. The general treatment of the subject is excellent, being based on adequate practical experience. The following passage (p. 139) is worth quoting. " No amount of reading or study can take the place of actual work with the maps. It is no more possible to become a synoptic meteorologist through reading than it is to become an analytical chemist or a practising physician."

The discussion of air masses is naturally based mainly on conditions in America. The colder parts of the Atlantic are mentioned as a " source region " for polar maritime air. Over the British Isles air masses often arrive from that region, but most of these, at least from mid-September to May, have come recently from a much colder snow covered area, which constitutes the real " source region". The term " source region " has a relative significance, as even over the snow covered areas conditions are frequently disturbed, and in such cases the air mass is unlikely to be in radiative equilibrium, or to have a negligibly small horizontal gradient of temperature aloft. The chapter headed " Weather Forecasting " is devoted entirely to Dr. Petterssen's rules, but the greater part of the book is relevant to forecast problems. Dr. Petterssen's recent work on frontogenesis also receives attention. Figs. 36 and 37 illustrate two types of frontogenesis off the south-east coast of America, due respectively to air movements and to locally produced temperature difference.

The two sets of charts do not present a striking contrast, and give the impression that the two factors are both operating in different degrees.

As one would expect in a book written mainly for air pilots, such vital factors as fogs, ice formation on aircraft, and warm front clouds are fully discussed. In a later edition there might with advantage be a fuller discussion of all kinds of cloud structure. The reviewer does not altogether agree with the remarks on turbulence and clouds on p. 58.

The more speculative questions do not enter greatly into the scope of the book. The treatment of cyclogenesis (pp. 86–87) is inadequate. It is said that a surface of discontinuity becomes steeper than its equilibrium position, that equilibrium is restored by the cold air pushing under the warm, and that this starts a cyclone. This has been said before, but has never been verified, and presents grave theoretical difficulty. If the angle of slope of the front decreases, and the difference of the pressure gradient on the two sides increases, as it generally does near the centre of a developing cyclone, the temperature difference must increase considerably, whether the sloping surface is in equilibrium or not. There is no evidence of this, and there is generally no way of producing it. A mere sharpening of the front at ground level is not enough. There would need to be an increase in the total temperature difference across the front in the free air, in order that the hypothesis should be applicable. The question of dynamical instability produced by excessive sheer at a steeply sloping front is different, and is more likely to be true.

Though difference of opinion on some points is inevitable, the book as a whole can be strongly recommended, especially from the practical point of view.

C. K. M. Douglas.

OBITUARY

We regret to learn of the death on December 14th, 1937, of Prof. Dr. Walter E. Bernheimer, Assistant at the Wiener Universitäts-Sternwarte.

NEWS IN BRIEF

We learn that Prof. H. Amorin Ferreira has been appointed Director of the Observatorio Central Meteorologico, Lisbon.

The Weather of January, 1938

Pressure was below 995 mb. from the south of Greenland to Bear Island (Iceland 988 mb.). Pressure was above 1025 mb. over the Azores and above 1035 mb. in Siberia, giving steep gradients for westerly winds across the Atlantic and British Isles, and for winds

from SSW. over Scandinavia and northern Russia. The Siberian anticyclone lay north-west of its normal position. Over southern and south-eastern Europe pressure was almost uniform, about 1017 mb. Another area below 1000 mb. extended from the Aleutian Is. to Kamschatka, but over most of North America pressure differed little from 1020 mb. The Faeroes and southern Sweden were more than 10 mb. below normal, while north-west Siberia had an excess of nearly 15 mb. Pressure was below normal over the whole of the British Isles, the greater part of Europe and southern Asia including India. The deviations were small over most of North America, but reached +4 mb. over Newfoundland, +5 mb. at Nome, Alaska and −6 mb. at Dawson.

The distribution of temperature was of great interest. The abnormally strong south-westerly winds carried warm air far into the Arctic and mean temperatures of 20° F. or more were reported from Spitsbergen and Novaya Zemlya. Bear Island was 10° F., the arctic coast of Siberia 15° F. and Novaya Zemlya 20° F. above normal. Even Jakutsk near the " cold pole " with a mean of −42° F. was 5° less cold than usual. The area of abnormal warmth included all Europe except the Mediterranean lands and the west coast of the British Isles, while parts of Sweden and Germany, the Soudan and a large area from the Black Sea to Turkestan were more than 5° F. above normal. On the other hand central Siberia, in the centre of the anticyclone, had temperatures 10° F. below normal. The greater part of northern and western North America was abnormally warm, the excess reaching 10° F. in western Canada.

Rainfall was generally above normal over Europe except for the Mediterranean coast, but in Siberia and most of North America it was deficient.

Temperature was below normal in the west and north of India but above over the Peninsula, Bengal and Indochina. The greater part of the area was rainless. No broadcast data were received for Australia and New Zealand.

A series of very deep depressions passed over the British Isles giving gales over most of the country during the month. Temperatures were generally high particularly during the latter half of the month, and at several places in the southern part of England the air temperature did not fall below 32° F. Sunshine was below normal except in the east of Scotland. At Aldergrove in Northern Ireland only 27 hrs. were recorded, a new low January record for this station. Rainfall was considerably above normal, south-west Scotland receiving more than 150 per cent. of the average. An anticyclone extended over Ireland and Scotland from the 1st to 5th and temperatures were low in England and Ireland on the 2nd and 3rd, and also in Scotland on the 3rd, Abbotsinch recording a minimum of 19° F. in the screen and 17° F. on the ground. Ireland had 5–6 hrs. of sunshine on the 2nd and 3rd, and southern Scotland on the 2nd and 4th. Snow fell in the Midlands and on the east coast on the 3rd.

Fog was reported locally on the 5th. Temperatures rose in England on the 7th and 8th as a depression approached from Iceland, and there was much sun generally on the 7th and on the east coast on the 8th, while rain spread from the west. Some fog occurred in Scotland and northern England. Heavy rain fell in Scotland and Northern Ireland on the 9th and some snow in south Scotland and the Midlands. A gale was reported from Kirkwall, and thunderstorms at Plymouth and the Channel Islands. On the 11th temperatures fell again and low minima were recorded in the north, Eskdalemuir reporting 18° F. in the screen. Snow fell locally and southern Scotland had fog and mist. In England temperatures rose generally until the 16th when a maximum of 57° F. was recorded at Sealand and 56° F. was reported from several stations. The deep depressions moving across the British Isles brought gales in Ireland and Scotland on the 12th–14th, and over the whole country on the 15th, see p. 4. Rain fell heavily on the 14th in England and Wales, 3·35 in. at New Dungeon Ghyll Hotel, Westmorland, and 3·08 in. at Watendlath Farm, Cumberland. On the 17th an interval of cold, sunny, quiet weather occurred as a ridge of high pressure passed eastwards across the country, the south coast experiencing over 6 hrs. sunshine. This was followed by rain in south Scotland, fog in the south and renewed westerly gales at Markree. A further sunny period occurred in south England on the 19th, but another deep depression brought squally winds in the west and further heavy rain on the 20th in the north-west, Borrowdale and New Dungeon Ghyll Hotel recording 2·09 in. and 2·08 in. respectively. Temperatures dropped in Scotland on the 21st but remained high in England ; fog was reported from the Midlands and south-east and became general on the 22nd when day temperatures rose throughout the country but sharp ground frosts occurred at night. A series of deep depressions centred over the British Isles until the end of the month maintained squally weather and gales were reported every day except the 26th, being particularly severe over the whole country on the 28th and 29th. Temperatures remained high in England and Ireland on the 23rd and 24th, Cardiff recording a maximum of 59° F. on the 23rd, and maxima of 57° F. being general on the 24th. Good sunshine records of over 7 hrs. were obtained in east and south England on the 24th. Thunderstorms occurred in Scotland on the 26th and temperature fell ; on the 27th Eskdalemuir reported a maximum of 35° F. Rain and hail fell generally in the north and north-west, but the south coast had 5–6 hrs. of sunshine. The 28th was cloudy, mild and sunless, and thunderstorms were reported from many parts both on the 28th and 29th and were accompanied by heavy hail showers. The east and south coasts again recorded sunshine on the 29th—Lympne 6·8 hrs. and Hastings 7·1 hrs. ; 6–7 hrs. was obtained on the east coast on the 30th, and a maximum record of 8·4 hrs. on the 31st at Dublin, but elsewhere there was little sun. The distribution of bright sunshine for the month was as follows :—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway ..	30	+ 3	Chester ..	51	− 2
Aberdeen ..	64	+17	Ross-on-Wye	45	−10
Dublin	56	− 1	Falmouth ..	49	−11
Birr Castle ..	36	−13	Gorleston ..	49	− 7
Valentia ..	46	+ 2	Kew.. ..	45	+ 1

Kew, Temperature, Mean, 43·5, Diff. from average + 2·2.

Miscellaneous notes on weather abroad culled from various sources. Severe cold was experienced in central and southern Europe at the beginning of the month, and heavy snowfalls were reported from Paris, Berlin, and many parts of Italy on the 4th. Ice formation on an aeroplane caused the death of 6 people in a crash on the same day. On the 5th the temperature over the whole of Germany was reported to be below freezing point, rivers were ice covered, 46° of frost was reported from east Hungary, and the lagoon and some canals were frozen in Venice. Many deaths resulted from the extreme cold in Italy and France. On the 6th gales were experienced in the North Sea and Black Sea: a thaw set in in Berlin, but while snow was lacking in Switzerland, heavy falls occurred in Austria, and Adriatic ports were icebound. In Bukowina and Sofia 50° of frost was reported, wolves appeared and many people were frozen to death. A north-west blizzard in the Sea of Marmora caused delay to shipping on the 8th. Heavy rains from the 10th–16th, and the melting of the snow during the thaw caused widespread floods in Belgium on the 13th–15th, Germany on the 15th and France on the 16th. The West Hinder lightship broke from her moorings during a violent storm on the 15th, and fog and storms were reported in the Bay of Biscay. Snow fell in Switzerland on the 21st and winter sports conditions improved. Fog was reported from Venice on the 20th and in the North Sea on the 24th. Storms swept the Channel and Atlantic coasts on the 29th and a severe gale caused much damage and loss of life in France. Heavy snow fell in the St. Gotthard region on the 30th and avalanches blocked the railway line for several days. Further avalanches in the Engadine and Piedmont on the 31st caused the death of 5 people. (*The Times*, January 3rd–February 1st.)

The total rainfall for the month was deficient in the Northern Territory and west Queensland, but generally above normal over the rest of Australia, being more than twice the normal on the north-east coast of New South Wales.—(*Cable*).

Glazed frost and heavy snow in the eastern United States on the 1st dislocated all traffic and resulted in the death of 55 people. Fog caused damage to shipping at Seattle on the 2nd. A gale sweeping across Oklahoma and Kansas on the 13th threatened the wheat crops. Low temperatures were recorded in New York on the 18th and storms extended along the Atlantic coast delaying shipping. Gales and high temperatures were reported from New York on the 24th, and an aeroplane pilot lost his way in the torrential rain. The

pressure of the ice pack caused the collapse of the Niagara Falls bridge on the 27th, and flood damage estimated at £200,000 was caused above the bridge. Temperatures again became low in New York on the 29th. (*The Times*, January 3rd–February 1st.)

Gales were reported from the Atlantic on the 5th, 14th–19th, 24th–25th, 30th–31st, causing much damage and delay to shipping. Severe storms in the Arctic on the 27th–31st threatened the safety of the Russian North Polar scientists. (*The Times*, January 8th–February 2nd.)

Daily Readings at Kew Observatory, January, 1938

Date	Pressure, M.S.L. 13h.	Wind, Dir., Force 13h.	Temp. Min.	Temp. Max.	Rel. Hum. 13h.	Rain.	Sun.	REMARKS. (see vol. 69, 1934, p. 1).
	mb.		°F.	°F.	%	in.	hrs.	
1	1027·8	NNW.4	37	44	75	—	0·1	r_0 10h., 23h.–24h.
2	1031·0	N.3	40	45	81	0·08	0·2	r_0 13h.–24h. [17h.
3	1033·3	NE.2	36	36	74	0·01	0·0	r_0 0h.–2h., s_0 14h.–
4	1024·6	NNW.3	33	43	90	trace	0·0	r_0 10h.–13h. and 17h.
5	1027·3	NW.2	36	41	87	trace	0·0	r_0 7h., 10h., 12h.
6	1020·4	W.3	38	42	77	0·03	0·0	r–r_0 22h.–24h.
7	998·0	SW.4	39	46	76	0·01	2·5	r_0 0h.–2h., 13h., 20h.
8	996·3	WSW.2	37	46	90	0·01	0·6	ir_0 15h.–19h.
9	980·1	WSW.4	43	44	68	0·07	2·1	r_0–r 1h.–6h.
10	977·1	NE.2	35	39	91	0·15	1·0	rs 12h., r_0 till 15h.
11	1001·0	S.3	32	46	91	0·08	0·1	rs 12h., r 13h.–14h.
12	1003·9	WSW.4	43	54	83	0·15	0·0	r 0h.–6h., 23h.–24h.
13	1008·9	SW.3	44	53	78	0·44	0·0	r_0 0h.–6h., r 14h.–18h.
14	1013·2	S.4	41	48	88	0·07	0·0	r–r_0 15h.–20h.
15	991·8	SW.6	47	50	65	0·12	0·2	r–r_0 0h.–7h.
16	1001·0	S.4	42	51	95	0·23	0·0	r–r_0 7h.–15h., r_0 19h.
17	1012·5	WNW.4	43	46	67	0·04	5·6	r–r_0 4h.–6h.
18	1013·2	S.4	34	45	77	trace	0·0	x early, d_0 21h.–24h.
19	1012·4	W.3	44	48	65	0·01	6·4	r_0 0h.–1h.
20	1023·1	SW.3	43	52	73	—	0·1	
21	1023·4	SW.3	47	50	91	trace	0·0	id_0 14h.–16h., Fx late.
22	1030·7	SSW.3	37	50	91	—	0·0	f 9h.
23	1034·0	SW.3	47	50	82	trace	2·0	w early.
24	1033·2	WSW.4	46	55	68	—	6·2	pr_0 late. [Aurora.
25	1018·9	SW.4	44	50	81	0·11	2·4	r–r_0 11h.–13h.,
26	1012·1	SW.5	37	47	71	0·15	3·1	r–r_0 16h.–18h.
27	1011·3	WNW.4	34	43	68	—	5·2	x early.
28	1001·6	SW.3	34	52	87	0·07	0·0	r–r_0 4h.–8h. [q 0h.–17h.
29	998·1	W.7	44	46	47	0·09	5·5	tl 3h., rs 12h.,
30	1007·3	WNW.4	39	46	64	0·20	1·3	r–r_0 0h.–3h., 4h.–6h.
31	1006·1	SSW.3	39	51	88	0·09	0·0	ir_0 till 21h., r 23h.
*	1012·1	—	40	47	78	2·23	1·4	* Means or Totals.

General Rainfall for January, 1938

England and Wales	147	per cent of the average 1881–1915.
Scotland	162	
Ireland	144	
British Isles ...	150	

Rainfall : January, 1938 : England and Wales

Co.	Station.	In.	Per cent of Av.	Co.	Station.	In.	Per cent of Av.
Lond .	Camden Square..........	2·78	149	*Leics* .	Thornton Reservoir ...	3·27	165
Sur .	Reigate, Wray Pk. Rd..	3·61	150	„ .	Belvoir Castle............	2·39	135
Kent .	Tenterden, Ashenden...	3·74	174	*Rut* .	Ridlington	2·68	145
„ .	Folkestone, Boro. San.	3·96	...	*Lincs* .	Boston, Skirbeck.........	2·64	163
„ .	Margate, Cliftonville....	2·66	160	„ .	Cranwell Aerodrome...	2·12	123
„ .	Eden'bdg., Falconhurst	3·84	157	„ .	Skegness, Marine Gdns.	2·06	119
Sus .	Compton, Compton Ho.	4·93	155	„ .	Louth, Westgate.........	1·98	91
„ .	Patching Farm..........	4·11	158	„ .	Brigg, Wrawby St.......	1·83	...
„ .	Eastbourne, Wil. Sq....	4·67	178	*Notts* .	Mansfield, Carr Bank...	2·61	121
Hants.	Ventnor, Roy.Nat.Hos.	3·80	148	*Derby*.	Derby, The Arboretum	3·05	146
„ .	Southampton,East Park	3·75	140	„ .	Buxton, Terrace Slopes	7·13	160
„ .	Ovington Rectory.......	3·86	143	*Ches* .	Bidston Obsy.............	2·70	127
„ .	Sherborne St. John......	3·04	131	*Lancs*.	Manchester, Whit. Pk.	3·83	153
Herts .	Royston,Therfield Rec.	2·62	151	„ .	Stonyhurst College......	6·25	146
Bucks.	Slough, Upton............	2·46	132	„ .	Southport, Bedford Pk.	3·45	135
Oxf .	Oxford, Radcliffe.........	2·65	146	„ .	Ulverston, Poaka Beck	5·19	120
N'hant	Wellingboro, Swanspool	2·80	151	„ .	Lancaster, Greg Obsy.	5·42	155
„ .	Oundle	2·03	...	„ .	Blackpool	3·77	138
Beds .	Woburn, Exptl. Farm...	2·49	146	*Yorks*.	Wath-upon-Dearne......	2·10	109
Cam .	Cambridge, Bot. Gdns.	2·59	173	„ .	Wakefield,Clarence Pk.	2·42	126
„ .	March.........................	2·48	155	„ .	Oughtershaw Hall.......	11·69	...
Essex .	Chelmsford,County Gdns	2·24	146	„ .	Wetherby, Ribston H..	...	...
„ .	Lexden Hill House......	2·84	...	„ .	Hull, Pearson Park......	1·88	104
Suff .	Haughley House..........	2·66	...	„ .	Holme-on-Spalding......	2·28	121
„ .	Rendlesham Hall........	2·65	146	„ .	Felixkirk, Mt. St. John.	2·75	137
„ .	Lowestoft Sec. School...	1·91	114	„ .	York, Museum Gdns....	2·15	121
„ .	Bury St. Ed., WestleyH.	3·54	198	„ .	Pickering, Hungate......	2·82	135
Norf. .	Wells, Holkham Hall...	2·29	158	„ .	Scarborough...............	2·78	139
Wilts .	Porton, W.D. Exp'l. Stn	2·79	121	„ .	Middlesbrough............	...	...
„ .	Bishops Cannings........	3·20	138	„ .	Baldersdale, Hury Res.	5·93	183
Dor .	Weymouth, Westham.	3·48	143	*Durh* .	Ushaw College............	2·17	106
„ .	Beaminster, East St....	4·38	126	*Nor* .	Newcastle, Leazes Pk...	1·95	98
„ .	Shaftesbury,Abbey Ho.	2·65	102	„ .	Bellingham, Highgreen	4·11	144
Devon.	Plymouth, The Hoe....	5·50	165	„ .	Lilburn Tower Gdns....	2·78	134
„ .	Holne, Church Pk. Cott.	14·31	232	*Cumb*.	Carlisle, Scaleby Hall...	3·33	134
„ .	Teignmouth, Den Gdns.	3·90	134	„ .	Borrowdale, Seathwaite	20·00	159
„ .	Cullompton	5·09	157	„ .	Thirlmere, Dale Head H.	14·31	176
„ .	Sidmouth, U.D.C.........	3·07	...	„ .	Keswick, High Hill......	7·56	150
„ .	Barnstaple, N. Dev.Ath	4·60	141	„ .	Ravenglass, The Grove	4·11	123
„ .	Dartm'r,Cranmere Pool	14·00	...	*West* .	Appleby, Castle Bank...	4·84	151
„ .	Okehampton, Uplands.	9·64	189	*Mon* .	Abergavenny, Larchf'd	4·23	125
Corn .	Redruth, Trewirgie......	6·34	150	*Glam* .	Ystalyfera, Wern Ho....	11·17	177
„ .	Penzance, Morrab Gdns.	5·53	146	„ .	Treherbert, Tynywaun.	15·73	...
„ .	St. Austell, Trevarna...	6·90	161	„ .	Cardiff, Penylan..........	5·78	157
Soms .	Chewton Mendip.........	5·48	143	*Carm* .	Carmarthen,M. & P. Sch.	8·36	186
„ .	Long Ashton..............	4·90	171	*Pemb* .	Pembroke,Stackpole Ct.	...	...
„ .	Street, Millfield...........	2·69	114	*Card* .	Aberystwyth	5·23	...
Glos .	Blockley	3·04	...	*Rad* .	BirmW.W.Tyrmynydd	10·42	165
„ .	Cirencester, Gwynfa....	3·92	156	*Mont* .	Newtown, Penarth Weir	...	...
Here .	Ross-on-Wye..............	2·63	109	„	Lake Vyrnwy	...	...
Salop .	Church Stretton..........	5·42	214	*Flint* .	Sealand Aerodrome......	3·28	176
„ .	Shifnal, Hatton Grange	3·30	170	*Mer* .	Blaenau Festiniog	15·71	168
„ .	Cheswardine Hall.......	3·27	148	„ .	Dolgelley, Bontddu......	7·45	131
Worc .	Malvern, Free Library...	3·11	141	*Carn* .	Llandudno	3·44	143
„ .	Ombersley, Holt Lock.	...	...	„ .	Snowdon, L. Llydaw 9..	27·40	...
War .	Alcester, Ragley Hall...	3·11	161	*Ang* .	Holyhead, Salt Island...	3·80	131
„ .	Birminghm, Edgbaston	3·09	153	„ .	Lligwy	5·44	...

Rainfall : January, 1938 : Scotland and Ireland

Co.	Station.	In.	Per cent of Av.	Co.	Station.	In.	Per cent of Av.
I. Man	Douglas, Boro' Cem....	5·16	154	*R&C* .	Achnashellach	13·33	139
Guern.	St.Peter P't.Grange Rd.	6·59	225	„ .	Stornoway,C.GuardStn.	7·11	145
Wig .	Pt. William, Monreith.	4·72	144	*Suth* .	Lairg........................	6·58	201
„ .	New Luce School.........	6·21	153	„ .	Skerray Borgie............	6·77	...
Kirk .	Dalry, Glendarroch......	8·39	151	„ .	Melvich......................	5·67	172
Dumf.	Dumfries,Crichton R.I.	4·97	164	„ .	Loch More, Achfary....	11·80	162
„ .	Eskdalemuir Obs.........	9·23	171	*Caith* .	Wick	3·54	144
Roxb .	Hawick, Wolfelee........	4·83	151	*Ork* .	Deerness	5·26	152
Peeb .	Stobo Castle..............	4·79	160	*Shet* .	Lerwick Observatory...	6·08	143
Berw .	Marchmont House......	2·77	123	*Cork* .	Cork, University Coll...	4·59	114
E.Lot .	North Berwick Res.....	2·63	153	„ .	Roches Point, C.G. Stn.	4·78	115
Midl .	Edinburgh, Blackfd. H.	3·32	189	„ .	Mallow, Longueville....	6·65	171
Lan .	Auchtyfardle	7·08	...	*Kerry* .	Valentia Observatory...	7·28	133
Ayr .	Kilmarnock, Kay Park	5·75	...	„ .	Gearhameen...............	...	...
„ .	Girvan, Pinmore.........	6·99	148	„ .	Bally McElligott Rec...	5·88	...
„ .	Glen Afton, Ayr San. ...	10·23	201	„ .	Darrynane Abbey.......	5·28	105
Renf .	Glasgow, Queen's Park	7·76	232	*Wat* .	Waterford, Gortmore...	3·91	107
„ .	Greenock, Prospect H..	10·14	157	*Tip* .	Nenagh, Castle Lough.	6·50	164
Bute .	Rothesay, Ardencraig...	8·73	194	„ .	Cashel, Ballinamona....	6·03	161
„ .	Dougarie Lodge..........	5·01	116	*Lim* .	Foynes, Coolnanes......	7·18	190
Arg .	Loch Sunart, G'dale....	12·93	183	*Clare* .	Inagh, Mount Callan....	10·48	...
„ .	Ardgour House..........	19·05	...	*Wexf* .	Gorey, Courtown Ho...	3·72	119
„ .	Glen Etive..................	21·41	204	*Wick* .	Rathnew, Clonmannon.	3·81	...
„ .	Oban.........................	11·00	...	*Carl* .	Bagnalstown,Fenagh H.	4·01	128
„ .	Poltalloch..................	9·26	183	„ .	Hacketstown Rectory...	4·34	122
„ .	Inveraray Castle.........	18·38	224	*Leix* .	Blandsfort House.......	5·16	157
„ .	Islay, Eallabus...........	6·74	144	*Offaly* .	Birr Castle................	4·39	155
„ .	Mull, Benmore............	16·40	121	*Kild* .	Straffan House...........	3·98	155
„ .	Tiree	6·51	153	*Dublin*	Dublin, Phoenix Park..	2·53	111
Kinr .	Loch Leven Sluice.......	6·11	194	„ .	Balbriggan, Ardgillan...	3·14	137
Fife .	Leuchars Aerodrome...	3·47	191	*Meath.*	Kells, Headfort..........	4·43	141
Perth .	Loch Dhu..................	14·30	157	*W.M* .	Moate, Coolatore.........	4·60	...
„ .	Crieff, Strathearn Hyd.	6·22	154	„ .	Mullingar, Belvedere...	4·87	152
„ .	Blair Castle Gardens....	5·90	177	*Long* .	Castle Forbes Gdns......	4·53	136
Angus.	Kettins School............	5·34	204	*Gal* .	Galway, Grammar Sch.	4·54	122
„ .	Pearsie House............	4·35	...	„ .	Ballynahinch Castle....	9·55	154
„ .	Montrose, Sunnyside...	2·88	145	„ .	Ahascragh, Clonbrock.	5·65	146
Aber .	Balmoral Castle Gdns..	4·62	167	*Rosc* .	Strokestown, C'node.....	4·27	136
„ .	Logie Coldstone Sch....	3·41	154	*Mayo* .	Blacksod Point...........	7·65	150
„ .	Aberdeen Observatory.	2·39	110	„ .	Mallaranny	8·74	...
„ .	New Deer School House	2·91	125	„ .	Westport House..........	6·04	130
Moray	Gordon Castle............	2·53	125	„ .	Delphi Lodge..............	14·09	142
„ .	Grantown-on-Spey	3·22	133	*Sligo* .	Markree Castle...........	6·04	155
Nairn.	Nairn	2·48	125	*Cavan* .	Crossdoney, Kevit Cas..	5·08	...
Inv's .	Ben Alder Lodge.........	12·89	...	*Ferm* .	Crom Castle...............	5·56	167
„ .	Kingussie, The Birches.	5·21	...	*Arm* .	Armagh Obsy.............	3·86	153
„ .	Loch Ness, Foyers	...	...	*Down.*	Fofanny Reservoir......	5·56	...
„ .	Inverness, Culduthel R.	3·89	153	„ .	Seaforde	4·24	135
„ .	Loch Quoich, Loan......	24·35	...	„ .	Donaghadee, C. G. Stn.	3·76	148
„ .	Glenquoich................	20·79	151	*Antr* .	Belfast,Queen's Univ....	4·73	165
„ .	Arisaig House............	8·40	135	„ .	Aldergrove Aerodrome.	3·55	130
„ .	Glenleven, Corrour......	...	...	„ .	Ballymena, Harryville.	5·25	141
„ .	Fort William, Glasdrum	15·50	...	*Lon* .	Garvagh, Moneydig....	5·12	...
„ .	Skye, Dunvegan..........	10·46	...	„ .	Londonderry, Creggan.	7·02	195
„ .	Barra, Skallary...........	6·07	...	*Tyr* .	Omagh, Edenfel.........	5·88	166
R&C.	Tain, Ardlarach..........	4·30	152	*Don* .	Malin Head...............	5·07	154
„ .	Ullapool	6·93	151	„	Dunkineely................	6·17	...

Climatological Table for the British Empire, August, 1937

STATIONS.	PRESSURE. Mean of Day M.S.L. (mb.)	PRESSURE. Diff. from Normal. (mb.)	TEMPERATURE. Absolute. Max. (°F.)	TEMPERATURE. Absolute. Min. (°F.)	TEMPERATURE. Mean Values. Max. (°F.)	TEMPERATURE. Mean Values. Min. (°F.)	TEMPERATURE. Mean Values. ½ Max. and Min. (°F.)	TEMPERATURE. Mean Values. Diff. from Normal. (°F.)	TEMPERATURE. Mean. Wet Bulb. (°F.)	Relative Humidity. (%)	Mean Cloud Am'nt (0–10)	PRECIPITATION. Am'nt. (in.)	PRECIPITATION. Diff. from Normal. (in.)	PRECIPITATION. Days.	BRIGHT SUNSHINE. Hours per day.	BRIGHT SUNSHINE. Percentage of possible.
London, Kew Obsy.	1018·2	+ 2·9	85	50	74·1	57·2	65·7	+ 4·0	57·7	86	6·6	2·98	+ 0·74	4	6·8	47
Gibraltar	1014·7	− 1·8	89	64	79·8	68·0	73·9	− 2·1	67·6	86	4·5	0·02	...	1	...	...
Malta	1014·3	− 0·5	91	70	85·2	73·6	79·4	+ 0·3	72·5	76	2·2	0·02	− 0·12	1	10·9	81
St. Helena	1016·0	− 1·4	63	53	60·4	54·7	57·5	+ 0·5	55·5	94	10·0	2·01	− 0·48	14	...	...
Freetown, Sierra Leone	1012·9	+ 1·8	86	70	80·7	72·2	76·5	...	74·3	90	8·7	39·77	+ 3·20	30	...	...
Lagos, Nigeria	1013·9	+ 0·9	86	70	81·9	74·1	78·0	+ 0·1	73·6	88	8·8	1·42	− 1·22	9	4·9	40
Kaduna, Nigeria	1011·4	...	89	66	82·4	68·6	75·5	+ 1·6	70·6	90	8·5	9·88	− 2·44	21	4·8	39
Zomba, Nyasaland	1017·1	+ 0·2	79	47	73·8	54·5	64·1	− 0·8	59·5	75	4·7	1·42	+ 1·05	6	...	...
Salisbury, Rhodesia	1020·5	+ 0·4	79	39	72·2	45·3	58·7	− 1·5	49·4	50	1·0	0·03	...	1	9·2	80
Cape Town	1021·2	+ 0·9	89	40	66·8	49·0	57·9	+ 2·3	50·6	84	5·0	1·37	− 2·00	10	...	...
Johannesburg	1021·3	+ 1·7	74	35	68·1	45·0	56·5	+ 2·1	43·8	42	0·7	0·00	− 0·51	0	9·7	87
Mauritius	1021·1	+ 0·5	77	54	75·0	61·5	68·3	− 0·2	64·6	72	5·1	2·96	+ 0·71	21	8·5	75
Calcutta, Alipore Obsy.	999·9	− 1·1	92	76	88·6	79·4	84·0	+ 0·8	79·7	89	9·0	14·10	+ 0·72	16*	...	...
Bombay	1005·9	0·0	87	75	85·3	76·8	81·1	+ 0·3	76·6	86	8·9	5·45	− 9·00	15*	...	...
Madras	1004·9	− 0·6	99	72	93·9	77·5	85·7	− 0·3	76·6	75	6·6	6·99	+ 2·45	10*	...	...
Colombo, Ceylon	1008·8	− 0·5	87	74	85·3	78·5	81·9	+ 0·7	76·9	76	7·3	2·12	− 1·12	13	6·7	55
Singapore	1009·1	− 0·4	89	73	86·4	78·4	82·4	+ 1·3	77·4	79	5·7	4·55	− 3·40	14	7·3	61
Hongkong	1004·2	− 0·6	93	76	86·1	79·0	82·5	+ 0·4	78·8	85	8·6	14·35	− 0·05	23	4·0	31
Sandakan	1008·3	...	92	73	89·4	75·2	82·3	+ 0·5	76·8	83	7·9	6·13	− 1·76	12	...	...
Sydney, N.S.W.	1019·5	+ 1·3	72	42	64·8	48·6	56·7	+ 1·7	51·4	74	4·9	4·15	+ 1·18	15	6·5	60
Melbourne	1019·4	+ 1·4	73	34	61·3	45·2	53·3	+ 2·3	47·9	73	7·0	1·31	− 0·56	13	4·3	41
Adelaide	1018·6	− 0·6	72	39	63·0	47·3	55·1	+ 1·1	50·6	71	7·9	3·40	+ 0·86	17	4·2	39
Perth, W. Australia	1018·1	− 0·8	74	39	64·3	48·2	56·3	+ 0·3	50·3	64	6·0	6·80	+ 1·15	18	6·0	55
Coolgardie	1018·8	− 0·5	75	33	63·3	39·5	51·4	− 2·2	45·3	65	2·8	0·63	− 0·36	6	...	...
Brisbane	1020·2	+ 1·0	78	44	69·8	51·8	60·8	+ 0·4	55·3	70	3·1	1·40	− 0·61	11	7·1	64
Hobart, Tasmania	1017·9	+ 4·5	67	32	57·3	43·0	50·1	+ 2·1	44·2	72	4·9	0·63	− 1·20	12	5·3	51
Wellington, N.Z.	1022·5	+ 7·4	61	37	54·3	43·0	48·7	+ 0·1	45·7	79	8·4	1·03	− 3·46	8	4·3	41
Suva, Fiji	1013·6	− 0·6	85	63	78·6	69·5	74·1	+ 0·5	70·6	87	7·2	11·46	+ 3·17	23	4·1	35
Apia, Samoa	1011·2	− 1·1	86	70	83·8	74·7	79·3	+ 1·5	75·1	78	5·7	6·26	+ 2·63	13	7·2	61
Kingston, Jamaica	1013·2	− 0·3	93	71	89·1	73·9	81·5	0·0	72·9	83	3·6	4·76	+ 1·21	10	8·6	68
Grenada, W.I.	1011·6	− 1·0	88	70	86	74	80	+ 0·3	73	74	5	8·58	− 0·75	22	...	...
Toronto	1017·6	+ 2·2	89	53	81·8	63·2	72·5	+ 5·3	65·1	86	5·5	2·89	+ 0·10	9	7·8	56
Winnipeg	1012·4	− 0·8	97	45	81·7	57·0	69·3	+ 5·5	56·7	88	4·3	2·12	− 0·04	11	8·7	60
St. John, N.B.	1017·0	+ 1·7	87	51	71·4	56·8	64·1	+ 3·5	59·9	89	7·5	1·66	− 2·20	16	6·8	48
Victoria, B.C.	1017·6	+ 0·7	79	48	67·1	51·6	59·3	− 0·4	55·5	80	4·9	1·55	+ 0·91	10	8·6	60

* For Indian stations a rain day is a day on which [illegible]

Victoria, B.C.	1017·6	+	0·7	79	48	67·1	51·6	59·3	−	0·4	55·5	80	4·9	1·55	+ 0·91	10	8·6	60